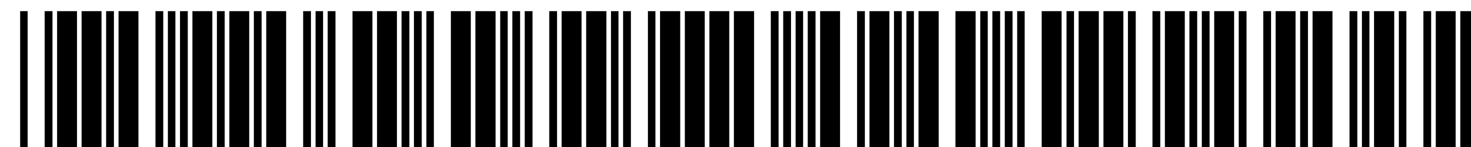

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(54) **FORMATION OF MASKS/RETICLES HAVING DUMMY FEATURES**

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G06F 17/50 (2006.01)

(52) **U.S. Cl.** **716/19**; 716/11; 716/21

(58) **Field of Classification Search** 716/11, 716/19, 21
See application file for complete search history.

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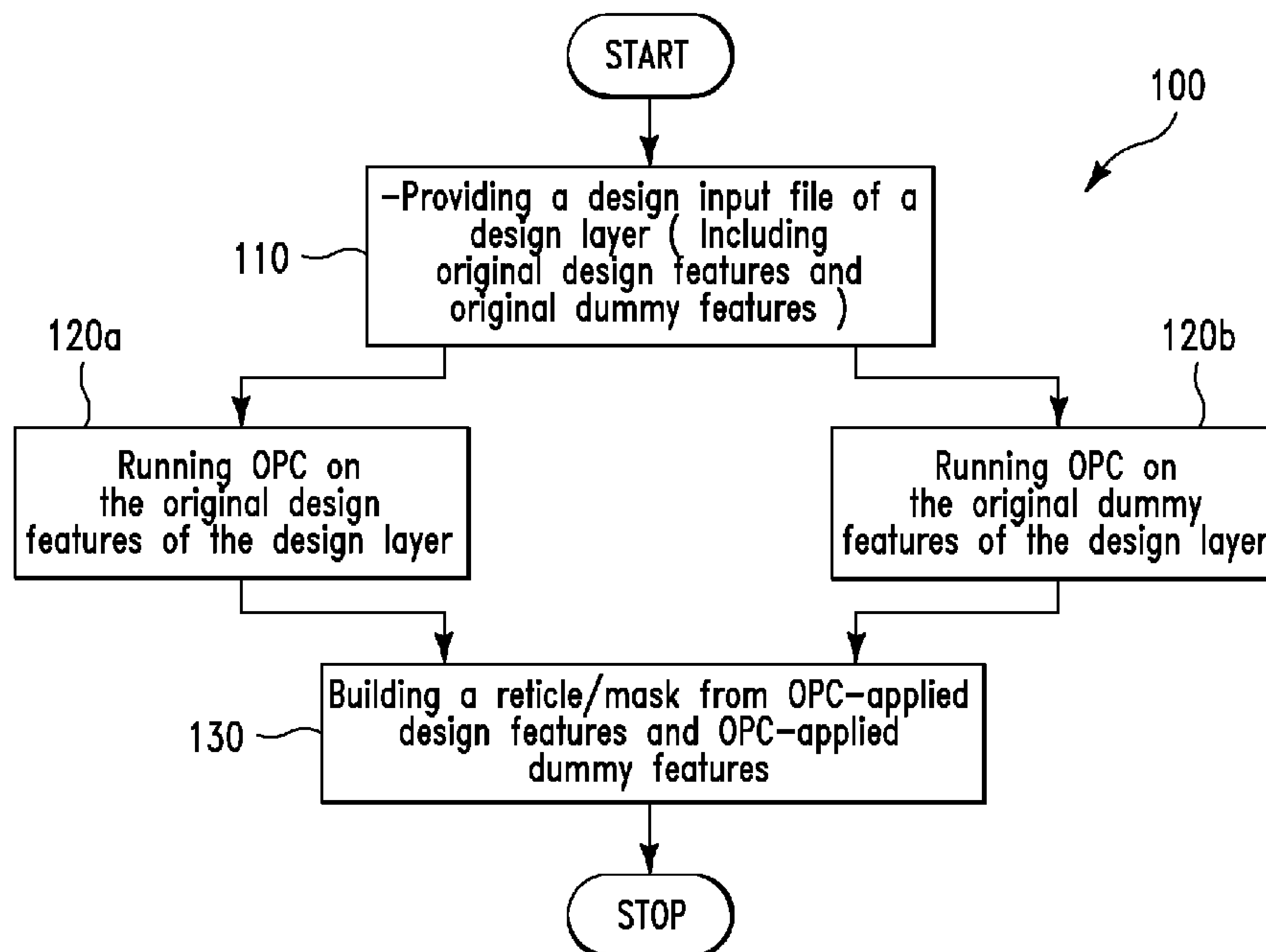
(57) **ABSTRACT**

Structures and methods for forming the same. The method includes providing design information of a design layer. The design layer includes M original design features and N original dummy features. The method further includes (i) creating a cluster of P representative dummy features, P being a positive integer less than N, (ii) performing OPC for the cluster of the P representative dummy features but not for the N original dummy features, resulting in P OPC-applied representative dummy features, and (iii) forming the mask including N mask dummy features. The N mask dummy features are identical. Each mask dummy feature of the N mask dummy features of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features. The N mask dummy features have the same relative positions as the N original dummy features.

35 Claims, 6 Drawing Sheets



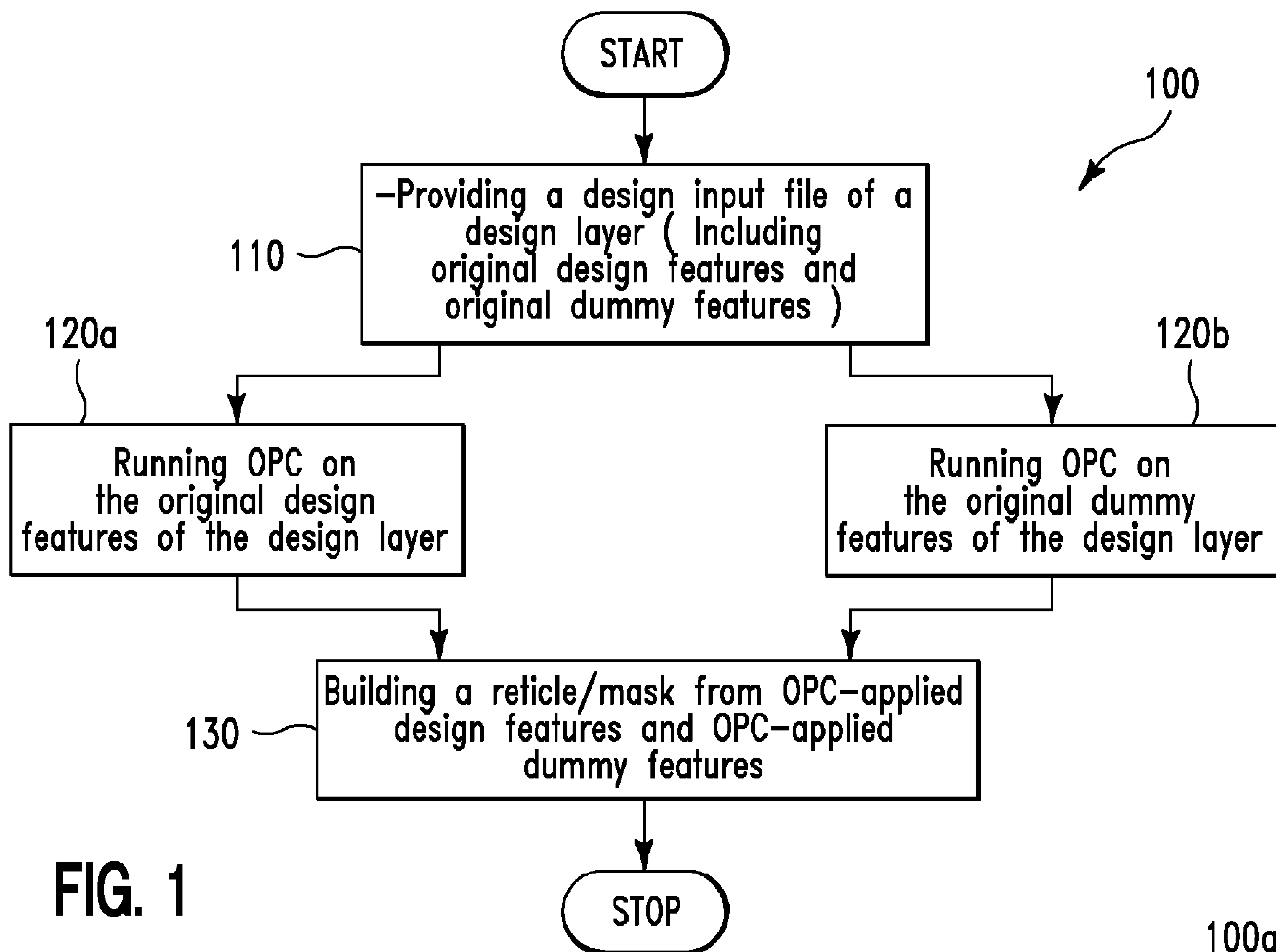


FIG. 1

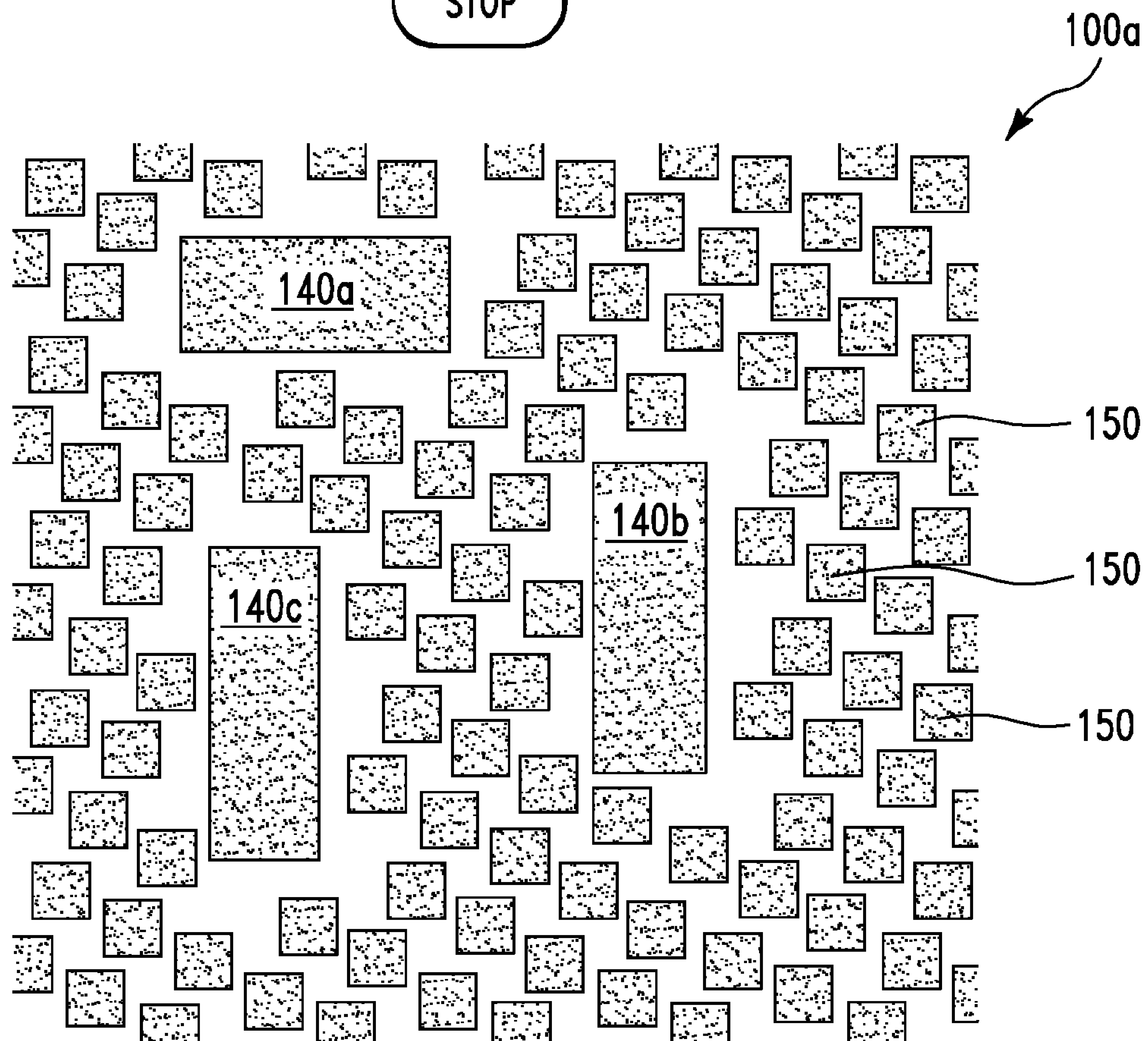


FIG. 1A

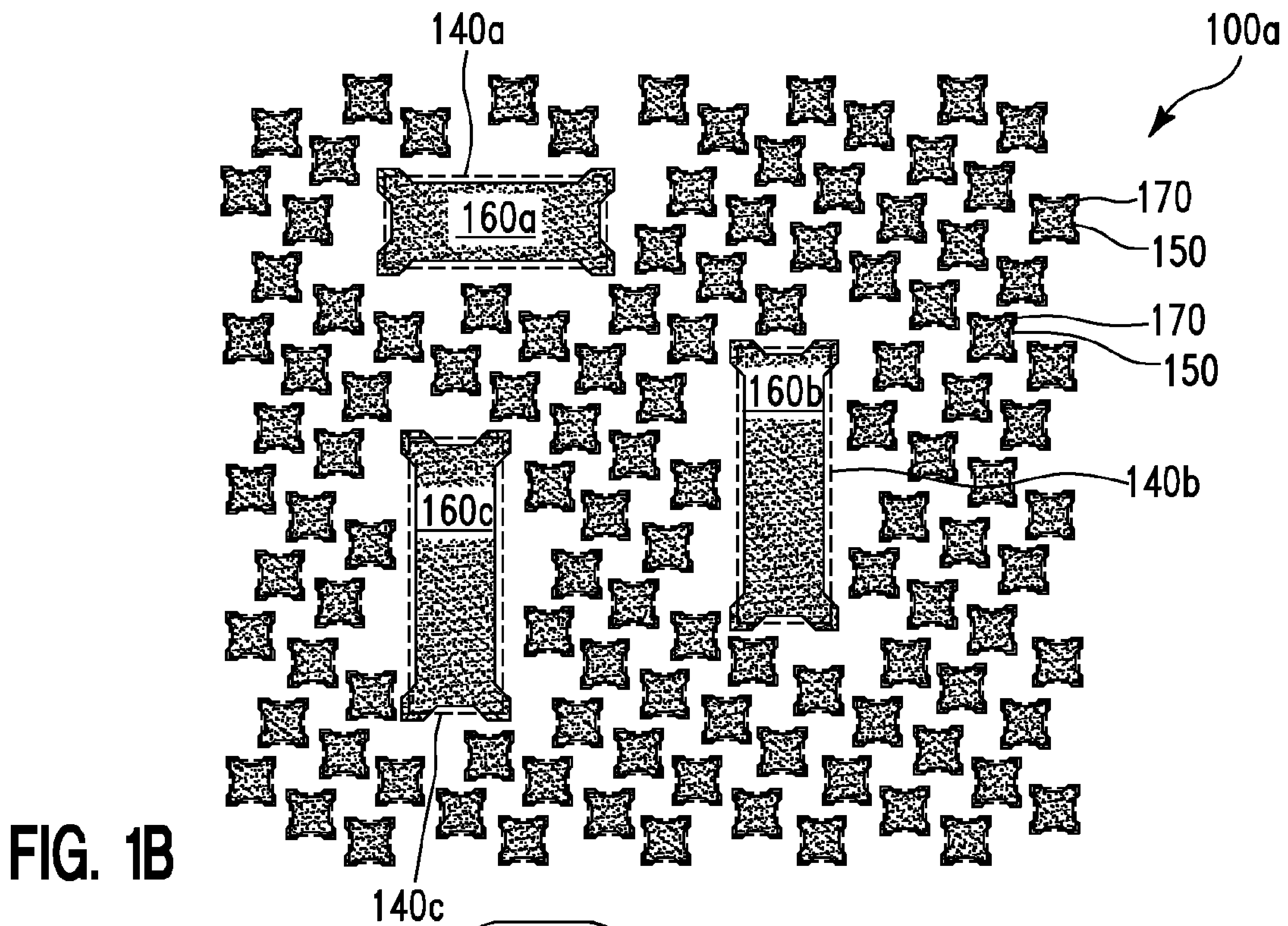


FIG. 1B

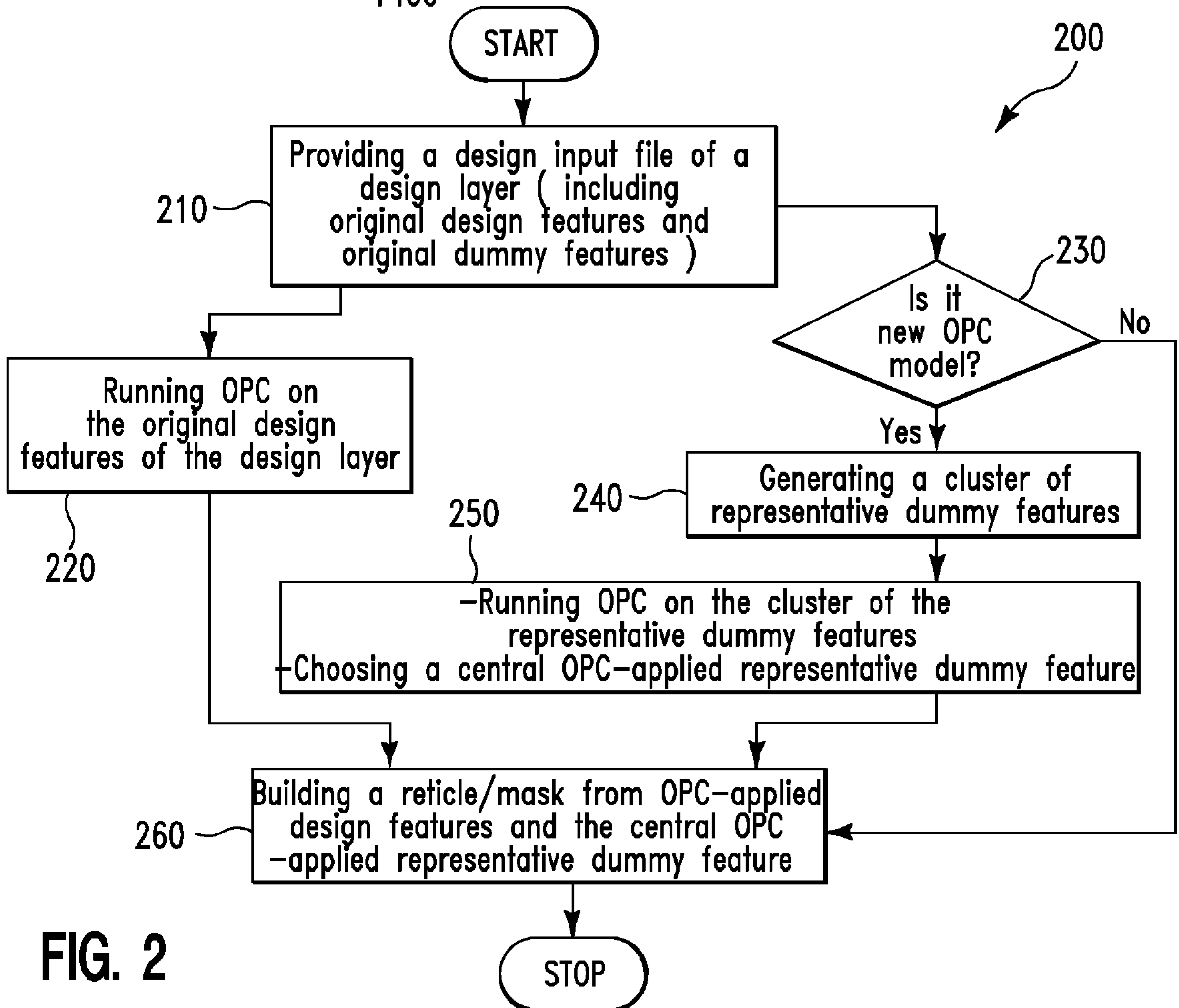


FIG. 2

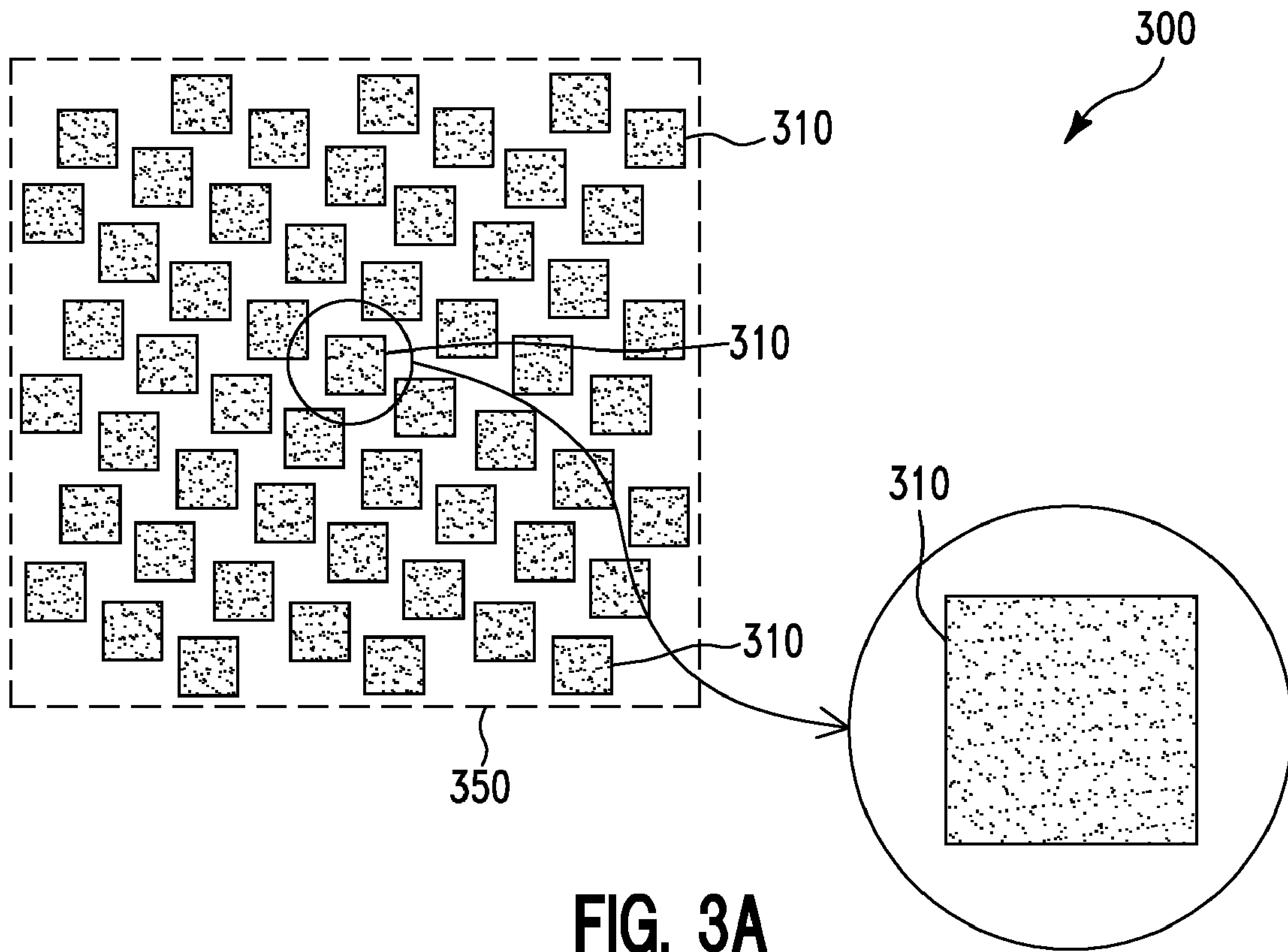


FIG. 3A

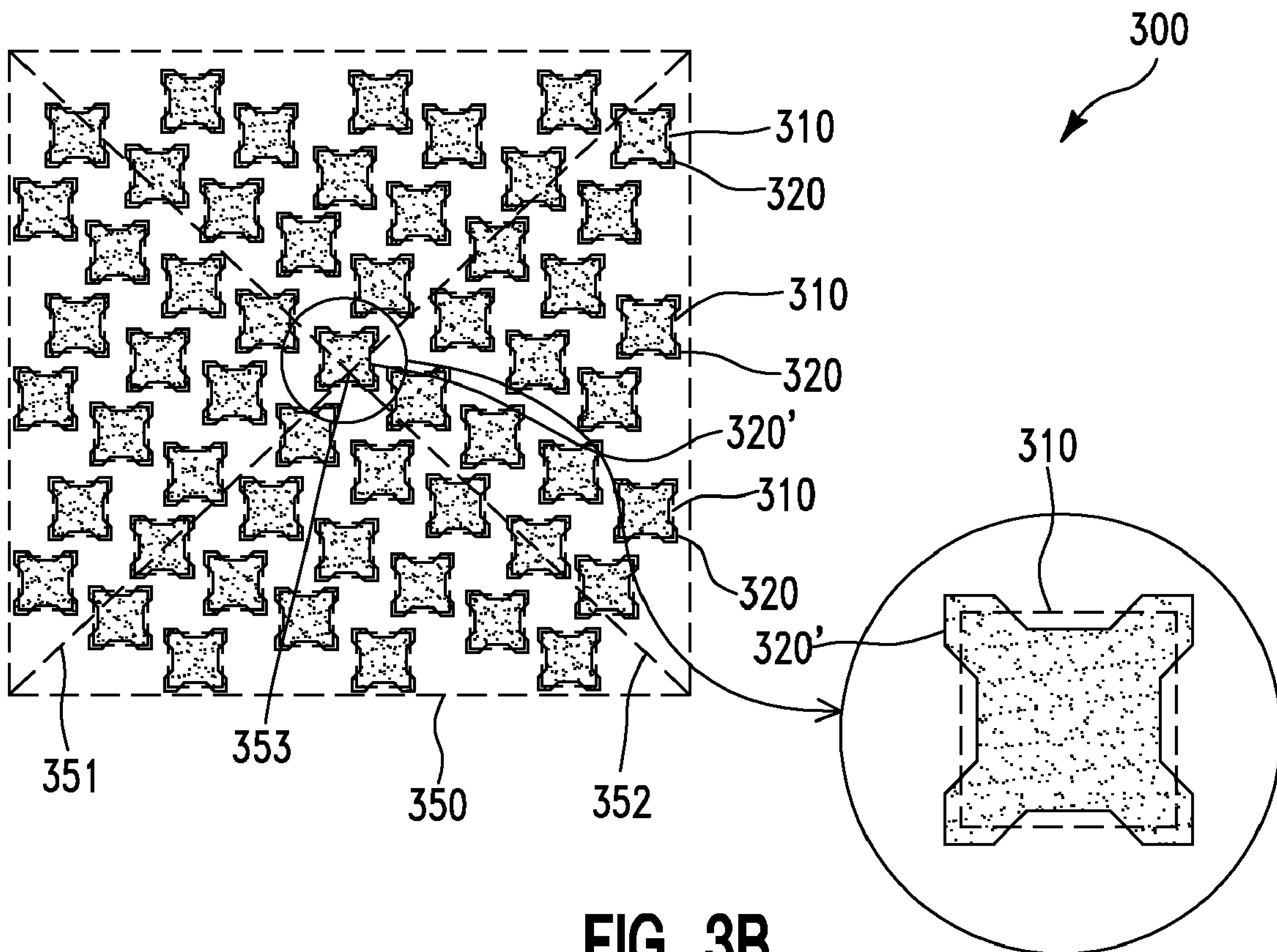


FIG. 3B

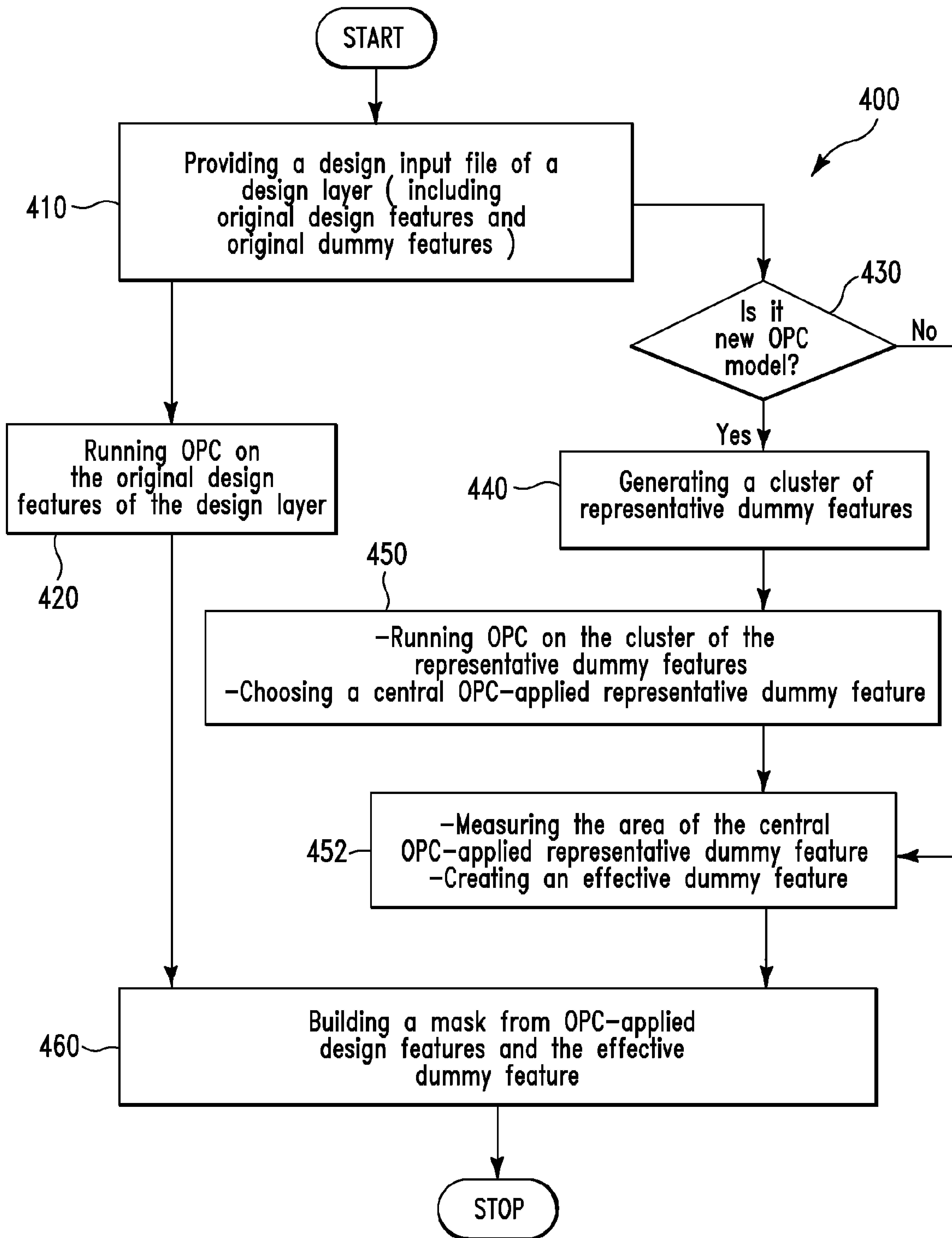


FIG. 4

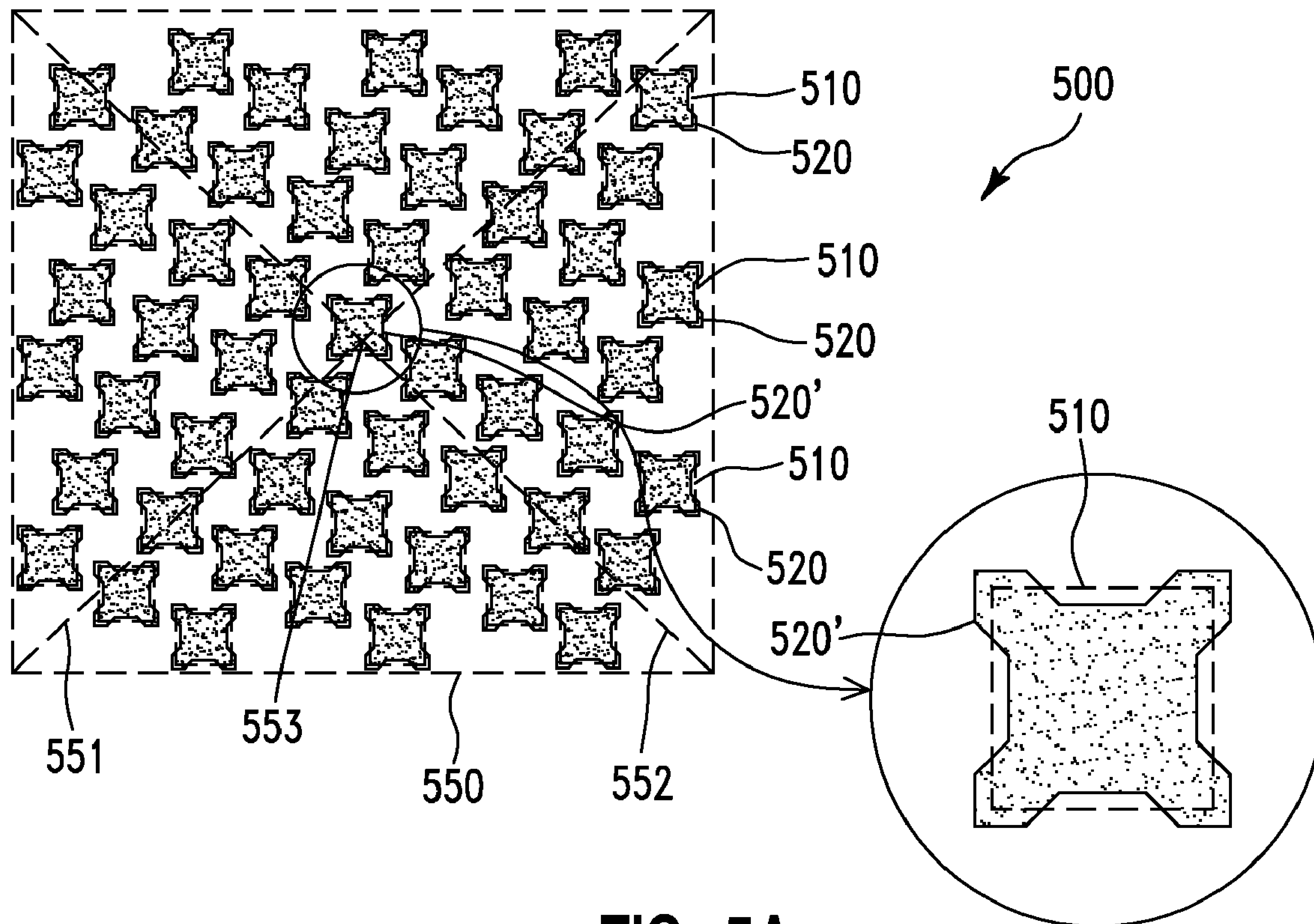


FIG. 5A

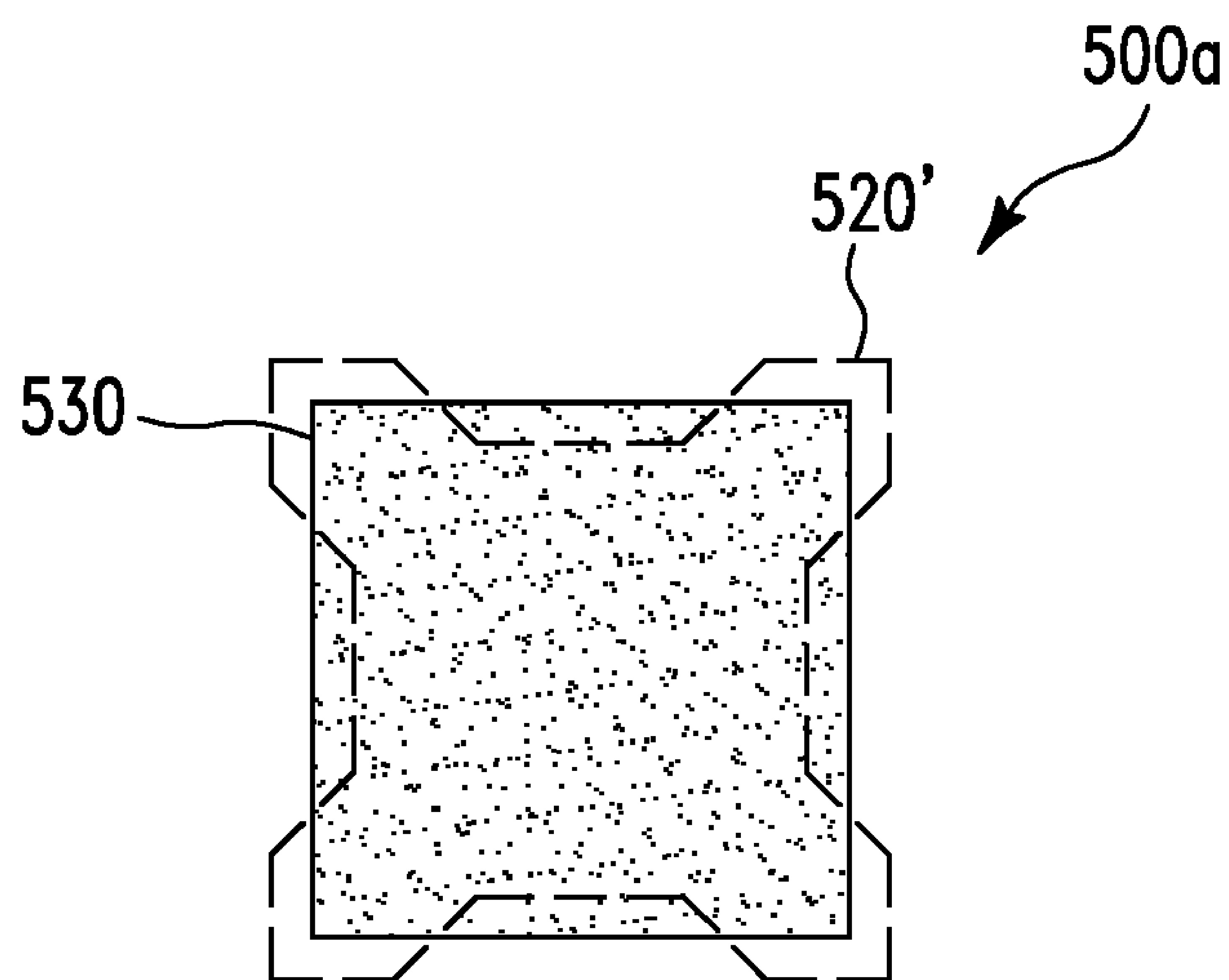


FIG. 5B

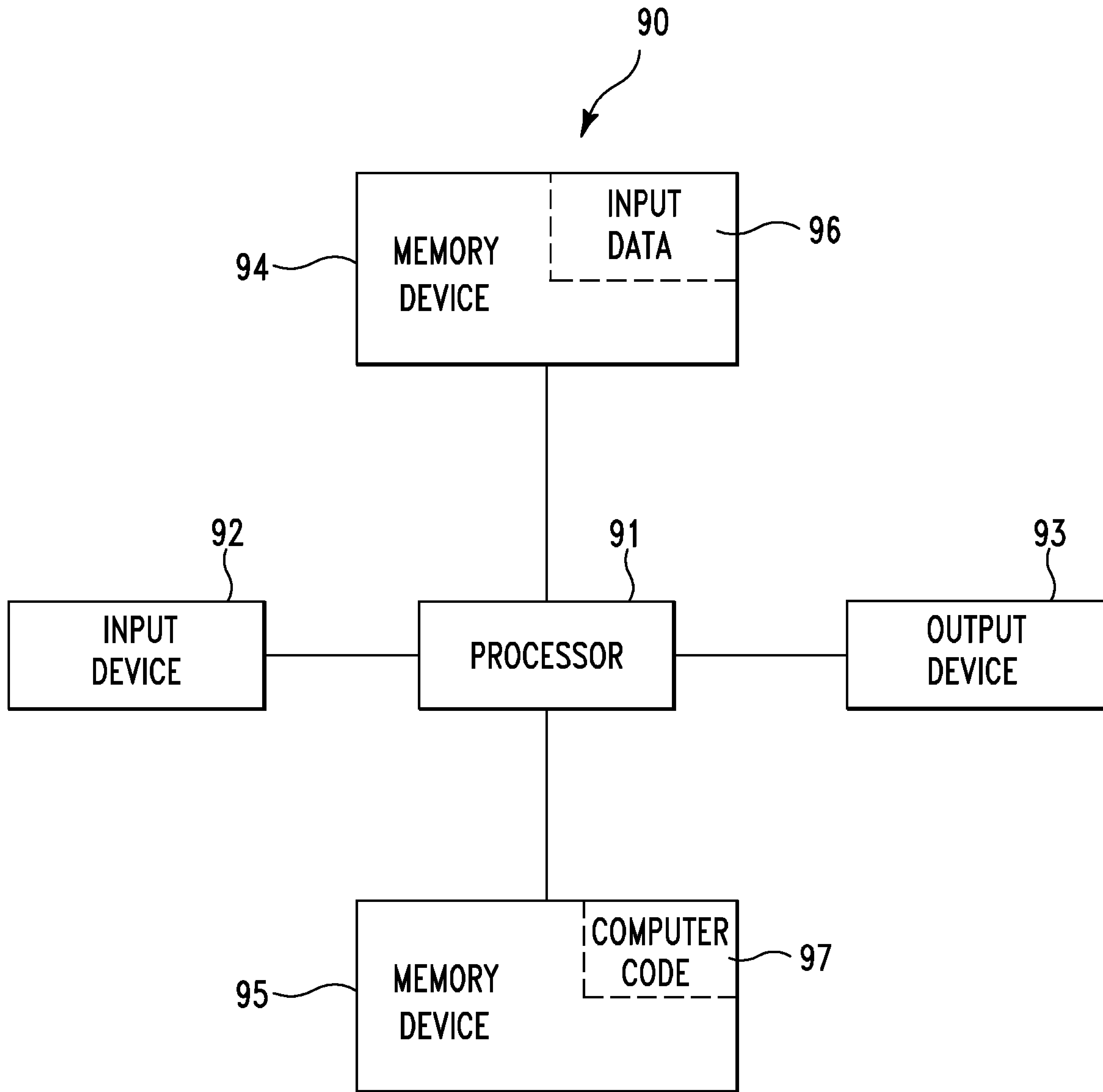


FIG. 6

FORMATION OF MASKS/RETICLES HAVING DUMMY FEATURES

FIELD OF THE INVENTION

The present invention relates to formation of masks/reticles, and more specifically, to formation of the masks/reticles having dummy features.

BACKGROUND OF THE INVENTION

In a conventional process of forming a mask for a design layer having M original design features and N original dummy features, an OPC (Optical Proximity Correction) program is typically run on characteristic data sets of the M original design features and the N original dummy features resulting in OPC-applied characteristic data sets of M OPC-applied design features and N OPC-applied dummy features, respectively. Next, the mask is formed from the OPC-applied characteristic data sets of the M OPC-applied design features, and the N OPC-applied dummy features. The numbers M and N are usually very large, and therefore running OPC program consumes a lot of time. Therefore, there is a need for a method for forming the mask that takes less time than in the prior.

SUMMARY OF THE INVENTION

The present invention provides a method of forming a mask, comprising providing design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers; creating a design cluster of P representative dummy features, P being a positive integer and less than N; performing OPC (Optical Proximity Correction) for the design cluster of the P representative dummy features but not for the N original dummy features, resulting in P OPC-applied representative dummy features such that if the P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the P representative dummy features would be created in the photoresist layer; forming the mask including N mask dummy features, wherein the N mask dummy features are identical, wherein each mask dummy feature of the N mask dummy features of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, and wherein the N mask dummy features have the same relative positions as the N original dummy features.

The present invention provides a computer system of claim **26**, wherein said creating the design cluster of the P representative dummy features comprises superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and using the area limited by the square as the design cluster of the P representative dummy features.

The present invention provides a method for forming the mask that takes less time than in the prior.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a flowchart of a method, in accordance with embodiments of the present invention.

FIGS. **1**A and **1**B illustrate the layout of the present invention.

FIG. **2** shows a flowchart of another method, in accordance with embodiments of the present invention.

FIGS. **3**A and **3**B illustrate a method of choosing a central OPC-applied representative dummy feature, in accordance with embodiments of the present invention.

FIG. **4** shows a flowchart of yet another method, in accordance with embodiments of the present invention.

FIGS. **5**A and **5**B illustrate a method of forming an effective dummy feature, in accordance with embodiments of the present invention.

FIG. **6** illustrates a computer system used for creating a mask for lithography including design features and dummy features, in accordance with embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** shows a flowchart of a method **100**, in accordance with embodiments of the present invention. The method **100** is for forming a photo mask/reticle (hereinafter, referred to as a mask) (not shown) for a design layer **100***a* (FIG. **1**A, top down view). The design layer **100***a* (FIG. **1**A) includes original design features **140***a*, **140***b*, and **140***c*, and original dummy features **150**. It should be noted that the design layer **100***a* may have large numbers of the original design features and the original dummy features but only the original design features **140***a*, **140***b*, and **140***c*, and the original dummy features **150** are shown for simplicity. As an example, assume that the design layer **100***a* has fifty thousand (50,000) features including ten thousand (10,000) original design features (similar to the original design features **140***a*, **140***b*, and **140***c* of FIG. **1**A) and forty thousand (40,000) original dummy features (similar to the original dummy features **150** of FIG. **1**A). This example will be referred to further below.

The original design features **140***a*, **140***b*, and **140***c* are features that are necessary for the operation of the design, whereas the original dummy features **150** are features that are not necessary for the operation of the design but are included in the design to make the pattern density of the mask more uniform across the design layer **100***a* during the fabrication process. In one embodiment, the original design features **140***a*, **140***b*, and **140***c* can be design trenches (not shown) in an interlevel dielectric layer, which are to be filled to form electrically conductive lines (not shown), whereas the original dummy features **150** can be dummy trenches, which are to be filled to form dummy lines (not shown). The detailed method **100** is as follows.

In one embodiment, the method **100** starts with a step **110** (FIG. **1**) in which a design input file of the design layer **100***a* (FIG. **1**A) is provided. The design input file contains a characteristic data set for each feature of the original design features **140***a*, **140***b*, and **140***c*, and the original dummy features **150**. The characteristic data set contains such information as shape, size, position, etc of the feature. All of the original dummy features **150** have the same shape and size. The original dummy features **150** have square shapes.

Next, in one embodiment, steps **120***a* and **120***b* (FIG. **1**) are performed. It should be noted that the steps **120***a* and **120***b* can be performed in any order. In the step **120***a*, an optical proximity correction (OPC) program is run on the characteristic data sets of the original design features **140***a*, **140***b*, and **140***c* (FIG. **1**A) resulting in OPC-applied characteristic data sets of OPC-applied design features **160***a*, **160***b*, and **160***c* (FIG. **1**B), respectively. It should be noted that the original design features **140***a*, **140***b*, and **140***c* are also shown in FIG. **1**B as dotted lines for comparison. The OPC program is run on one characteristic data set of an original design feature after

another. OPC is a photolithography enhancement technique commonly used to compensate for design errors due to diffraction or process effects. The OPC program is a software run by a computer system (not shown). In the example above, the OPC program is run on the 10,000 characteristic data sets of the 10,000 original design features (similar to the original design features **140***a*, **140***b*, and **140***c* of FIG. **1**A) resulting in the 10,000 OPC-applied characteristic data sets of 10,000 OPC-applied design features (similar to the OPC-applied design features **160***a*, **160***b*, and **160***c* of FIG. **1**B), respectively.

In the step **120***b* (FIG. **1**), in one embodiment, the OPC program is run on the characteristic data sets of the original dummy features **150** (FIG. **1**A) resulting in OPC-applied characteristic data sets of OPC-applied dummy features **170** (FIG. **1**B), respectively. It should be noted that the original dummy features **150** are also shown in FIG. **1**B as dotted lines for comparison. The OPC program is run on one characteristic data set of an original dummy feature **150** after another. In the example above, the OPC program is run on the 40,000 characteristic data sets of the 40,000 original dummy features (similar to the original dummy features **150** of FIG. **1**A) resulting in the 40,000 OPC-applied dummy features of 40,000 OPC-applied dummy features (similar to the OPC-applied dummy features **170** of FIG. **1**B), respectively.

Next, in step **130** (FIG. **1**), in one embodiment, the mask is built from the OPC-applied characteristic data sets of (i) the OPC-applied design features **160***a*, **160***b*, and **160***c* (the result of step **120***a*), and (ii) the OPC-applied dummy features **170** (the result of step **120***b*). In the example above, the mask is built having the 10,000 OPC-applied design features and the 40,000 OPC-applied dummy features.

FIG. **2** shows a flowchart of a method **200**, in accordance with embodiments of the present invention. The method **200** is for forming a photo mask/reticle (hereinafter, referred to as a mask) (not shown) for the design layer **100***a* (FIG. **1**A, top down view). The detailed method **200** is as follows.

In one embodiment, the method **200** starts with a step **210** (FIG. **2**). The step **210** of the method **200** is similar to the step **110** of the method **100** (FIG. **1**).

Next, in one embodiment, steps **220** and **230** (FIG. **2**) are performed. The step **220** of the method **200** is similar to the step **120***a* of the method **100** (FIG. **1**). In the example above, the OPC program is run on the 10,000 characteristic data sets of the 10,000 original design features (similar to the original design features **140***a*, **140***b*, and **140***c* of FIG. **1**A) resulting in 10,000 OPC-applied characteristic data sets of 10,000 OPC-applied design features (similar to the OPC-applied design features **160***a*, **160***b*, and **160***c* of FIG. **1**B), respectively.

In the step **230** (FIG. **2**), in one embodiment, it is determined whether the OPC model is new. If no, then this means that steps **240** and **250** have previously been performed for this OPC model already. Therefore, a step **260** of the method **200** is performed. If the answer to the question in the step **230** is affirmative, then the step **240** of the method **200** is performed.

In the step **240**, in one embodiment, a design cluster **300** of representative dummy features **310** (FIG. **3**A, top down view) is generated. More specifically, in one embodiment, the design cluster **300** is generated by superimposing an imaginary square **350** of a predetermined size on an area of the design layer **100***a* (FIG. **1**A) such that only original dummy features **150** are inside the square **350**. Then, such area can be used as the design cluster **300**, and therefore, the original dummy features **150** inside the square **350** become the representative dummy features **310** of FIG. **3**A. The number of the representative dummy features **310** of the design cluster **300** can be less than two hundred. The circle on the right of FIG. **3**A is an enlarged view of one representative dummy feature **310**. In the example above, the generated design cluster **300** comprises, illustratively, one hundred (100) representative dummy features **310** (as shown in FIG. **3**A) that represent the 40,000 original dummy features **150** (FIG. **1**A).

Next, in the step **250** (FIG. **2**), in one embodiment, the OPC program is run on the characteristic data sets of the representative dummy features **310** (FIG. **3**A) resulting in OPC-applied characteristic data sets of OPC-applied representative dummy features **320** (FIG. **3**B), respectively. It should be noted that the representative dummy features **310** are also shown in FIG. **3**B as dotted lines for comparison. In the example above, the OPC program is run on the 100 characteristic data sets of the 100 representative dummy features **310** resulting in the 100 OPC-applied characteristic data sets of the 100 OPC-applied representative dummy features **320**, respectively.

Next, in one embodiment, a central OPC-applied representative dummy feature **320'** is chosen as follows. Firstly, an intersection point **353** of two diagonals **351** and **352** of the imaginary square **350** is determined (as shown in FIG. **3**B). Next, if the intersection point **353** is within an OPC-applied representative dummy feature, that OPC-applied representative dummy feature is chosen as the central OPC-applied representative dummy feature **320'**. If the intersection point **353** is not within any the OPC-applied representative dummy features **320**, the OPC-applied representative dummy feature nearest the intersection point **353** is chosen as the central OPC-applied representative dummy feature **320'**. In FIG. **3**B, the central OPC-applied representative dummy feature **320'** is circled and the large circle on the right of FIG. **3**B is an enlarged view of the central OPC-applied representative dummy feature **320'**.

Next, in step **260** (FIG. **2**), in one embodiment, the mask is built from the OPC-applied characteristic data sets of (i) the OPC-applied design features (similar to the OPC-applied design features **160***a*, **160***b*, and **160***c* of FIG. **1**B), and (ii) the central OPC-applied representative dummy feature **320'**. In the example above, the mask is built having the 10,000 OPC-applied design features (the result of step **220**) and 40,000 mask dummy features identical in terms of size and shape to the central OPC-applied representative dummy feature **320'**. The 40,000 mask dummy features are located at the same locations as the 40,000 original dummy features. Therefore, the mask dummy features (i.e., the 40,000 mask dummy in this example) have the same relative positions as the original dummy features (i.e., the 40,000 original dummy features in this example.

In summary, instead of running the OPC program on the 40,000 characteristic data sets of the 40,000 original dummy features as in method **100**, the OPC program is run on only the 100 characteristic data sets of the 100 representative dummy features **310** as in method **200**. The OPC program is not run on the 40,000 original dummy features. Then, one of the resulting 100 OPC-applied representative dummy features **320** (i.e. the central OPC-applied representative dummy feature **320'**) is used for forming all 40,000 mask dummy features of the mask. As a result, the 40,000 mask dummy features are identical in terms of size and shape to the central OPC-applied representative dummy feature **320'**. The resulting 100 OPC-applied representative dummy features are such that: if the 100 OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the 100 representative dummy features would be created in the photoresist layer.

FIG. **4** shows a flowchart of a method **400**, in accordance with embodiments of the present invention. The method **400** is for forming a photo mask/reticle (hereinafter, referred to as a mask) (not shown) for the design layer **100**_a_ (FIG. **1**A, top down view). The detailed method **400** is as follows.

In one embodiment, the method **400** starts with a step **410** (FIG. **4**). The step **410** of the method **400** is similar to the step **110** of the method **100** (FIG. **1**).

Next, in one embodiment, steps **420** and **430** (FIG. **2**) are performed. The step **420** of the method **400** is similar to the step **120**_a_ of the method **100** (FIG. **1**). In the example above, the OPC program is run on the 10,000 characteristic data sets of the 10,000 original design features (similar to the original design features **140**_a_, **140**_b_, and **140**_c_ of FIG. **1**A) resulting in 10,000 OPC-applied characteristic data sets of 10,000 OPC-applied design features (similar to the OPC-applied design features **160**_a_, **160**_b_, and **160**_c_ of FIG. **1**B), respectively.

In the step **430** (FIG. **4**), in one embodiment, it is determined whether the OPC model is new. If no, then this means that steps **440**, **450**, and **452** have previously been performed for this OPC model already. Therefore, a step **460** of the method **400** is performed. If the answer to the question in the step **430** is affirmative, then the step **440** of the method **400** is performed.

In the step **440**, in one embodiment, a design cluster **500** (similar to the design cluster **300** of FIG. **3**A) of representative dummy features **510** (as shown in FIG. **5**A as dotted lines for comparison) is generated. The step **440** of the method **400** is similar to the step **240** of the method **200**. In the example above, the design cluster **500** comprises, illustratively, 100 representative dummy features **510** (FIG. **5**A) that represent the 40,000 original dummy features **150** (FIG. **1**A).

Next, in the step **450** (FIG. **4**), in one embodiment, the OPC program is run on the characteristic data sets of the representative dummy features **510** (FIG. **5**A) resulting in OPC-applied characteristic data sets of OPC-applied representative dummy features **520** (as shown in FIG. **5**A), respectively. Next, a central OPC-applied representative dummy feature **520'** is chosen. The step **450** of the method **400** is similar to the step **250** of the method **200**. In the example above, the OPC program is run on the 100 characteristic data sets of the 100 representative dummy features **510** resulting in the 100 OPC-applied characteristic data sets of the 100 OPC-applied representative dummy features **520**, respectively. In FIG. **5**A, the central OPC-applied representative dummy feature **520'** is circled and the large circle on the right of FIG. **5**A is an enlarged view of the central OPC-applied representative dummy feature **520'**.

Next, in the step **452** (FIG. **4**), in one embodiment, the area of the central OPC-applied representative dummy feature **520'** is measured. Next in a first embodiment, an effective dummy feature **530** (as shown in FIG. **5**B) is created whose area is equal to the area of the central OPC-applied representative dummy feature **520'** (as shown in FIG. **5**B as dotted line for comparison). In a second embodiment, the area of the effective dummy feature **530** is equal to the average area of the 100 OPC-applied representative dummy features **520** (in the example above). The effective dummy feature **530** has a square shape. Therefore, the effective dummy feature **530** of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature **520'**. As examples, the area of the effective dummy feature **530** is equal to: (i) the area of the central OPC-applied representative dummy feature **520'**in the preceding first embodiment: and (ii) average area of the 100 OPC-applied representative dummy features **520** in the preceding first embodiment.

Next, in step **460** (FIG. **4**), in one embodiment, the mask is built from the OPC-applied characteristic data sets of (i) the OPC-applied design features (similar to the OPC-applied design features **160**_a_, **160**_b_, and **160**_c_ of FIG. **1**B), and (ii) the effective dummy feature **530** of the FIG. **5**B. In the example above, the mask is built having the 10,000 OPC-applied design features (the result of step **420**) and the 40,000 mask dummy features identical in terms of size and shape to the effective dummy feature **530**. The 40,000 mask dummy features are located at the same locations as the 40,000 original dummy features.

In summary, instead of running the OPC program on the 40,000 characteristic data sets of the 40,000 original dummy features as in method **100**, the OPC program is run on only the 100 characteristic data sets of the 100 representative dummy features **510** as in method **400**. Then, the effective dummy feature **530** is created and used for forming all 40,000 mask dummy features of the mask. As a result, the 40,000 mask dummy features are identical in terms of size and shape to the effective dummy feature **530**. In the embodiments described above, the design information of the design layer **100**_a_ (FIG. **1**A) can be stored in a design file which in turn can be stored in a memory device (not shown) such as a computer hard disk. The design clusters **300** and **500** (FIGS. **3**A and **5**A, respectively) can be stored in a separate file which can be stored in the same hard disk as the design file or in a different memory device. The OPC-applied features (design or dummy) can also be stored in files which can be stored in the same memory device as the design file or in a different memory devices.

FIG. **6** illustrates a computer system **90** used for creating a mask for lithography including design features and dummy features, in accordance with embodiments of the present invention. The computer system **90** comprises a processor **91**, an input device **92** coupled to the processor **91**, an output device **93** coupled to the processor **91**, and memory devices **94** and **95** each coupled to the processor **91**. The input device **92** may be, inter alia, a keyboard, a mouse, etc. The output device **93** may be, inter alia, a printer, a plotter, a computer screen, a magnetic tape, a removable hard disk, a floppy disk, etc. The memory devices **94** and **95** may be, inter alia, a hard disk, a floppy disk, a magnetic tape, an optical storage such as a compact disc (CD) or a digital video disc (DVD), a dynamic random access memory (DRAM), a read-only memory (ROM), etc. The memory device **95** includes a computer code **97**. The computer code **97** includes an algorithm for creating a mask for lithography including design features and dummy features. The processor **91** executes the computer code **97**. The memory device **94** includes input data **96**. The input data **96** includes input required by the computer code **97**. The output device **93** displays output from the computer code **97**. Either or both memory devices **94** and **95** (or one or more additional memory devices not shown in FIG. **9**) may be used as a computer usable medium (or a computer readable medium or a program storage device) having a computer readable program code embodied therein and/or having other data stored therein, wherein the computer readable program code comprises the computer code **97**. Generally, a computer program product (or, alternatively, an article of manufacture) of the computer system **90** may comprise said computer usable medium (or said program storage device).

While FIG. **6** shows the computer system **90** as a particular configuration of hardware and software, any configuration of hardware and software, as would be known to a person of ordinary skill in the art, may be utilized for the purposes stated supra in conjunction with the particular computer system **90**

of FIG. 6. For example, the memory devices 94 and 95 may be portions of a single memory device rather than separate memory devices.

While particular embodiments of the present invention have been described herein for purposes of illustration, many modifications and changes will become apparent to those skilled in the art. Accordingly, the appended claims are intended to encompass all such modifications and changes as fall within the true spirit and scope of this invention.

The invention claimed is:

1. A method of forming a mask, comprising:

providing design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers;

creating a design cluster of P representative dummy features, P being a positive integer and less than N;

performing OPC (Optical Proximity Correction) for the design cluster of the P representative dummy features but not for the N original dummy features, resulting in P OPC-applied representative dummy features such that if the P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the P representative dummy features would be created in the photoresist layer;

forming the mask including N mask dummy features,

wherein the N mask dummy features are identical,

wherein each mask dummy feature of the N mask dummy features of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, and

wherein the N mask dummy features have the same relative positions as the N original dummy features.

2. The method of claim **1**, wherein the design information is included in a design input file.

3. The method of claim **1**, wherein all of the N original dummy features have the same shape and size.

4. The method of claim **1**, wherein the N original dummy features have square shape.

5. The method of claim **1**, wherein the N mask dummy features have square shape.

6. The method of claim **1**, further comprising performing OPC for the M original design features resulting in M OPC-applied design features such that if the M OPC-applied design features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the M original design features would be created in the photoresist layer.

7. The method of claim **6**, wherein the mask further includes M mask design features which are identical in terms of size and shape to the M OPC-applied design features.

8. The method of claim **1**, wherein said creating the design cluster of the P representative dummy features comprises:

superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and

using the area limited by the square as the design cluster of the P representative dummy features.

9. The method of claim **8**, further comprising, after said creating the design cluster of P representative dummy features is performed, selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features,

wherein if an intersection point of two diagonals of the square is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature is nearest the intersection point, and

wherein if the intersection point of the two diagonals of the square is within an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature includes the intersection point.

10. The method of claim **9**, wherein the N mask dummy features are identical in terms of size and shape to the selected OPC-applied representative dummy feature.

11. The method of claim **9**, wherein the area of each mask dummy feature of the N mask dummy features is equal to an area of the selected OPC-applied representative dummy feature.

12. The method of claim **1**, wherein the area of each mask dummy feature of the N mask dummy features is equal to an average area of the P OPC-applied representative dummy features.

13. A method of forming a mask, comprising:

providing design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers; creating a design cluster of P representative dummy features, P being a positive integer and less than N;

performing OPC (Optical Proximity Correction) for the M original design features and the design cluster of the P representative dummy features but not for the N original dummy features, resulting in M OPC-applied design features and P OPC-applied representative dummy features, respectively such that if the M OPC-applied design features and P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the M original design features and the design cluster of the P representative dummy features would be created in the photoresist layer;

creating an effective dummy feature, wherein the effective dummy feature has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features; and

forming the mask including M mask design features and N mask dummy features,

wherein the M mask design features are identical in terms of size and shape to the M OPC-applied design features,

wherein the M mask design features have the same relative positions as the M original design features,

wherein the N mask dummy features are identical in terms of size and shape to the effective dummy feature, and

wherein the N mask dummy features have the same relative positions as the N original dummy features.

14. The method of claim **13**, wherein the effective dummy feature has square shape.

15. The method of claim **13**, wherein said creating the design cluster of the P representative dummy features comprises:

superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and

using the area limited by the square as the design cluster of the P representative dummy features.

16. The method of claim **15**, further comprising, after said creating the design cluster of P representative dummy features is performed, selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features,

wherein if an intersection point of two diagonals of the square is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature is nearest the intersection point, and

wherein if the intersection point of the two diagonals of the square is within an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature includes the intersection point.

17. The method of claim **15**, wherein the area of the effective dummy feature is equal to an area of the selected OPC-applied representative dummy feature.

18. The method of claim **13**, wherein the area of the effective dummy feature is equal to an average area of the P OPC-applied representative dummy features.

19. A computer system comprising a processor and a computer readable memory unit coupled to the processor, said memory unit containing instructions that when executed by the processor implement a method for creating a design of a mask, said method comprising the computer-implemented steps of:

receiving design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers;

creating a design cluster of P representative dummy features, P being a positive integer and less than N;

performing OPC (Optical Proximity Correction) for the design cluster of the P representative dummy features but not for the N original dummy features, resulting in P OPC-applied representative dummy features such that if the P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the P representative dummy features would be created in the photoresist layer; and

creating the design of the mask, said mask including N mask dummy features,

wherein the N mask dummy features are identical,

wherein each mask dummy feature of the N mask dummy features of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, and

wherein the N mask dummy features have the same relative positions as the N original dummy features.

20. The computer system of claim **19**, wherein the N mask dummy features have square shape.

21. The computer system of claim **19**, wherein said method further comprises the step of performing OPC for the M original design features resulting in M OPC-applied design features such that if the M OPC-applied design features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the M original design features would be created in the photoresist layer.

22. The computer system of claim **21**, wherein the mask further includes M mask design features which are identical in terms of size and shape to the M OPC-applied design features.

23. The computer system of claim **19**, wherein said creating the design cluster of the P representative dummy features comprises:

superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and

using the area limited by the square as the design cluster of the P representative dummy features.

24. The computer system of claim **23**, wherein said method further comprising, after said creating the design cluster of P representative dummy features is performed, selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features,

wherein if an intersection point of two diagonals of the square is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature is nearest the intersection point, and

wherein if the intersection point of the two diagonals of the square is within an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature includes the intersection point.

25. The computer system of claim **24**, wherein the N mask dummy features are identical in terms of size and shape to the selected OPC-applied representative dummy feature.

26. A computer program product, comprising a computer readable storage medium having a computer readable program code stored therein, wherein the computer readable program code upon being executed by a processor of a computer system implements a method for creating a design of a mask, said method comprising:

receiving design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers; creating a design cluster of P representative dummy features, P being a positive integer and less than N;

performing OPC (Optical Proximity Correction) for the design cluster of the P representative dummy features but not for the N original dummy features, resulting in P OPC-applied representative dummy features such that if the P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the P representative dummy features would be created in the photoresist layer; and

creating the design of the mask, said mask including N mask dummy features,

wherein the N mask dummy features are identical,

wherein each mask dummy feature of the N mask dummy features of the mask has an area which is a function of at least an area of an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, and

wherein the N mask dummy features have the same relative positions as the N original dummy features.

27. The computer program product of claim **26**, wherein P is less than two hundred.

28. The computer program product of claim **26**,

wherein said creating the design cluster of the P representative dummy features comprises: superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and using

the area limited by the square as the design cluster of the P representative dummy feature, and

said method further comprising, after said creating the design cluster of P representative dummy features is performed, selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features,

wherein if an intersection point of two diagonals of the square is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature is nearest the intersection point, and

wherein if the intersection point of the two diagonals of the square is within an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature includes the intersection point.

29. The computer program product of claim **28**, wherein the selected OPC-applied representative dummy feature of the P OPC-applied representative dummy features is nearest the intersection point of two diagonals of the square and the intersection point is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features.

30. The computer program product of claim **28**, wherein the intersection point of two diagonals of the square is within the selected OPC-applied representative dummy feature of the P OPC-applied representative dummy features.

31. A method of forming a mask, comprising:

providing design information of a design layer, wherein the design layer includes M original design features and N original dummy features, M and N being positive integers;

creating a design cluster of P representative dummy features, P being a positive integer and less than N;

performing OPC (Optical Proximity Correction) for the M original design features and the design cluster of the P representative dummy features but not for the N original dummy features, resulting in M OPC-applied design features and P OPC-applied representative dummy features, respectively such that if the M OPC-applied design features and P OPC-applied representative dummy features were printed on the mask and if a lithographic process was performed on a photoresist layer through the printed mask, then the M original design features and the design cluster of the P representative dummy features would be created in the photoresist layer;

selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features; and

forming the mask including M mask design features and N mask dummy features,

wherein the M mask design features have the same relative positions as the M original design features, and

wherein the N mask dummy features have the same relative positions as the N original dummy features.

32. The method of claim **31**, wherein the M mask design features are identical in terms of size and shape to the M OPC-applied design features, and wherein the N mask dummy features are identical in terms of shape to the selected OPC-applied representative dummy feature of the P OPC-applied representative dummy features.

33. The method of claim **31**,

wherein said creating the design cluster of the P representative dummy features comprises: superimposing a square of a predetermined size on an area of the design layer such that only P original dummy features of the N original dummy features are inside the square; and using the area limited by the square as the design cluster of the P representative dummy feature, and

said method further comprising, after said creating the design cluster of P representative dummy features is performed, selecting an OPC-applied representative dummy feature of the P OPC-applied representative dummy features,

wherein if an intersection point of two diagonals of the square is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature is nearest the intersection point, and

wherein if the intersection point of the two diagonals of the square is within an OPC-applied representative dummy feature of the P OPC-applied representative dummy features, the selected OPC-applied representative dummy feature includes the intersection point.

34. The method of claim **33**, wherein the selected OPC-applied representative dummy feature of the P OPC-applied representative dummy features is nearest the intersection point of two diagonals of the square and the intersection point is not within any OPC-applied representative dummy feature of the P OPC-applied representative dummy features.

35. The method of claim **33**, wherein the intersection point of two diagonals of the square is within the selected OPC-applied representative dummy feature of the P OPC-applied representative dummy features.

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